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MOSQUITOES AND BATS.

By L. O. HOWARD, M. D., Ph. D., Chief, Bureau of Entomology, Department of Agriculture; Consulting Entomologist, United States Public Health Service.¹

The insect-feeding habits of bats have long been known, and that among these insects are mosquitoes is also a matter of ancient knowledge. In a work entitled "A History of British Mammals," by G. E. H. Barrett-Hamilton, Part II, November, 1910, page 115, in writing about the bat of England, or flitter mouse (*Pipistrellus pipistrellus*), the writer says "The fondness of this animal for different species of gnats has been observed from the time when Pliny wrote (although probably of a different species) '*et in cibatu culices gratissimi*,' and it is probable that these little flies constitute no small part of its usual food." This would indicate that knowledge of the mosquito-feeding habits of bats dates back to the Roman times.

In modern times I find a note on page 221 of Entomological News for September, 1901, in an account of the meeting of the Feldman Collecting Social (a social entomological society of Philadelphia), held June 10, 1901, the following words: "Mr. Seiss mentioned dissecting a specimen of the common brown bat whose stomach was full of mosquitoes." This quotation was printed on page 179 of Volume I, of the Monograph of the Mosquitoes of North and Central America and the West Indies, Carnegie Institution of Washington, 1912 (Howard, Dyar, and Knab), with the following general statement under the central heading "Bats:" "Bats are important mosquito-destroying animals. Flying at dusk and after dark and capturing all flying insects upon the wing, they devour large numbers of adult mosquitoes in times of mosquito prevalence." It is further stated in the same place that the suggestion has been made by Mr. A. C. Weeks, of Brooklyn, that an attempt be made to breed bats artificially on account of their importance as mosquito destroyers. I can not remember the earliest date on which Mr. Weeks made this suggestion to me, but he has done it many times on occasions of my annual visits to Brooklyn, which began in 1894 and continued until recently. In the same place attention was called to the building of a bat breeding-house near San Antonio, Tex., by Dr. Charles A. R. Campbell of that city, whose idea was

¹ Read at the Third Annual Meeting of the New Jersey Mosquito Extermination Association, Atlantic City, N. J., Feb. 17-18, 1916, and published in the Proceedings of the Meeting.

that the bats would become sufficiently numerous in this special nesting-place to rid the neighborhood of night-flying mosquitoes, calling attention to the fact that the expense of the building would be more than paid by the collection of the resulting bat guano.

Previous to the publication of the Carnegie Monograph there had appeared a privately printed pamphlet by Edward Cecil Bessellieu, of Charleston, S. C., in 1906, in which he urged the construction of bat-roosts for the purpose of doing away with mosquitoes and malaria. He wrote: "Nature's plea to man is in this connection 'Build and maintain bateries,' encourage the bat to multiply and release him in malarious localities, and find 'surcease of sorrow.' "

In 1910 Dr. Charles A. R. Campbell, of San Antonio, Tex., who had been corresponding with me for a number of years about other matters, sent me a long article on the practical use of bats in ridding a locality of malaria, and wrote me at the same time that he proposed to make the study of bats his life's work; that he advanced the idea of cultivating bats on account of their insect-destroying qualities more than 10 years previously, but that 2 years before (1908) he gained the idea of the commercial element of gathering the guano collecting at a specially constructed roost. This idea he got by watching bats defecate and weighing the product. His idea was that the hygienic value of the roost would not cause it to be built, but that the dollars and cents would, and the hygienic value would follow. He had constructed a roost at the experimental farm of the Bureau of Plant Industry of the U. S. Department of Agriculture, some 6 miles south of San Antonio, and since that time he has published a number of newspaper articles, has secured the indorsement of the San Antonio Academy of Medicine and the Bexar County Medical Society, and the idea of bat roosts in malarious localities has thus spread far and wide over the country and is naturally attractive on account of its simplicity and on account of the possible commercial gain.

I have not looked into the question of commercial gain, but from the standpoint of mosquito destruction and consequent relief from malaria, I have felt impelled to make certain investigations, which, however, have not gone so far as to induce actual experimentation by the erection of an experimental bat-roost in any part of the country.

Rather glowing claims are made in San Antonio concerning the disappearance of malaria in the vicinity of the bat-roosts erected, and these are fortified by the sworn statements of certain Mexican families residing in the neighborhood before and after the roosts were erected.

During 1913 and 1914 I directed Mr. F. C. Bishopp, in charge of the field laboratory of the Bureau of Entomology at Dallas, Tex.,

to visit San Antonio and investigate the Campbell bat-roost and the relation of bats to mosquitoes and the prevalence of malaria. Mr. Bishopp went to San Antonio on several occasions and made observations concerning bats and mosquitoes, not only there but at Uvalde and along the foothills north of that town where myriads of the common bat of that region live in the numerous limestone caves. He reported that Dr. Campbell's first bat-roost was built in 1909 on the Experimental Farm of the Bureau of Plant Industry of the Department of Agriculture, but the bats were not induced to live in this roost; at the time of Mr. Bishopp's visit it was not occupied by them. In 1910 another bat-roost, with slight modifications, was built at the head of Mitchell Lake, some 10 miles from San Antonio. This lake is formed by the sewage from the city of San Antonio, and certain portions of its margins seemed to offer excellent breeding places for malarial mosquitoes. The bats were successfully established in this building, and at the time of one of Mr. Bishopp's visits, August 26, 1914, the emergence flight of the bats was noticed. He estimated that not to exceed nine thousand bats emerged, although Dr. Campbell estimated that the house is capable of accommodating 250,000 bats. At the time of this visit the amount of guano which had accumulated was almost negligible.

The district about Mitchell Lake is not within the corporate limits of San Antonio, and the cases of malaria had not been reported, so that no statistics are available to determine the relative prevalence of the disease before and since the construction of the roost. Inquiry which Mr. Bishopp made among the employees of the land company, with headquarters at the lower end of the lake, about 3 miles from the roost, seemed to show that there was no apparent difference in the abundance of mosquitoes or the prevalence of malaria before and after the construction of the roost. In all cases the inhabitants reported mosquitoes to be extremely abundant, and the company's store reported that there was a good demand for chill tonics. Around the head of the lake, near the bat-roost, the Mexicans interviewed reported favorably on the effect of the roost. Mr. Bishopp, however, made an examination of the premises of one of these Mexican tenants, about one-third of a mile from the roost, and found that mosquitoes were present in exceedingly large numbers. They were hidden in the dark corners of the chicken-house and the calf-pen, but no examination was made of the dwelling. All were *Anopheles pseudopunctipennis*. It appears from Mr. Bishopp's report that San Antonio is in a region where bats are normally extremely abundant. The prevalent species is the free-tailed bat, *Nyctinomus mexicanus*, a species which roosts in great numbers in deserted houses (in large numbers in that vicinity), and the numerous caves among the hills several miles away furnish suitable breeding

places for great numbers, which come into the plains nightly for the purpose of feeding. The report further states that at Uvalde, and in the foothills to the northward, where bats are extremely abundant, mosquitoes often cause considerable annoyance at night. On certain occasions when Mr. Bishopp's party camped in the foothills not far from where millions of bats roost, they were annoyed by night-flying mosquitoes. A marked illustration of how mosquitoes may breed in great numbers in the presence of great numbers of bats is shown by an observation which Mr. Bishopp's party made at the time of one of their visits to the Frio bat-cave north of Uvalde. It seems that the bat guano is removed from this cave once or twice a year and that during this process the workmen camp at the cave for about two weeks. When they reached the cave in the fall of 1914 they were greatly annoyed at night by mosquitoes, which were said to be more abundant than they had ever seen them anywhere. When they entered the cave they found that they had left a barrel of water in its mouth the previous spring and that this was responsible for the pests, which disappeared in a few days after the barrel had been emptied.

Mr. Bishopp collected a considerable number of bats as they returned to the bat-cave, and preserved the stomachs; and a large number of slide mounts of the stomach contents of the bats so taken were examined by specialists in the U. S. National Museum. On the first lot of slides the only insect remains which were recognized were scales, legs, antennæ, wings, and bodies of Lepidopterous insects (small moths). They were too badly disintegrated for close naming. In the second series of slides were found remains of Carabidæ, especially *Agonoderus*; of Jassidæ, especially *Agallia*; of Tipulidæ, the eggs of Noctuidæ, and the eggs and remains of other Lepidoptera. Nothing resembling mosquito remains was found in the entire series. During the fall of 1914, and on a few occasions in 1915, the feeding habits of this bat were observed by Mr. Bishopp about arc-lights. They were repeatedly seen catching moths of various kinds, and seemed to show an especial liking for very large noctuids, which were quickly devoured. His conclusions on the whole are that these bats are very general insect feeders, seeming to show a decided preference for moths; but he considers it probable that a good many mosquitoes are destroyed among the other insects, especially when larger insects are scarce.

Mr. Bishopp's description of the Campbell bat-roost is as follows:

The Campbell bat-roost consists of a sort of tower set on four posts about 10 feet above the ground. According to Dr. Campbell, the size of the roost may be varied considerably. As I recall them, the dimensions of the roost at Mitchell Lake are about as follows: Twelve feet square at the bottom, the walls slanting inward toward

the top, which is about 6 feet square. Height, about 20 feet. On the outside, the building is covered with drop siding with tar paper beneath. The roof is shingled and projects over the edges. It is slightly elevated so as to permit of the entrance and exit of the bats. Additional entry space is allowed entirely down one side of the building. This opening, which is about $2\frac{1}{2}$ feet wide, is provided with boards slanting upward so as to exclude light to some extent but allows the bats to enter between them. The central portion of the house from the side provided with the entrance to the opposite side is unobstructed from top to bottom, thus leaving an air space about $2\frac{1}{2}$ feet wide. On each side of the shaft, and running to the two other sides of the building, is a series of shelves made of matched flooring. These shelves slant upward and outward at an angle of about 30° . In the first house constructed, these shelves were about 5 inches apart, but I believe in the later model they are closer together. Wire netting is tacked on top of each of the shelves so as to provide places for the bats to hang. The slant is given so as to allow the guano to roll down and drop into the center of the bottom structure, which is provided with trapdoors opening downward. This is to permit of the emptying of the manure into a wagon which is placed under the roost.

The following interesting letter bearing on this subject was received in 1912 from Dr. Byrd, the well-known health officer of Florida:

STATE BOARD OF HEALTH OF FLORIDA,
Jacksonville, Fla., June 26, 1912.

Dr. L. O. HOWARD,
Chief of Bureau of Entomology,
Washington, D. C.

DEAR DOCTOR: Some 20 years ago, perhaps longer, at Tavares, Fla., a development company undertook to build a winter resort. Tavares was at the time a small municipality with perhaps two or three hundred inhabitants, located among the lakes in the southern part of the State.

Among the earlier efforts at development an opera house was constructed, but owing to the freeze of 1895 it was never completed. The municipality never grew to amount to anything; in fact, I think the number of inhabitants now is what it was about then. The doors and windows of the lower floor of this opera house were securely fastened up to keep intruders out, but the upper windows were only closed by loose boards, which soon dropped out, making it easily accessible to bats. They took advantage of it, and in the course of a few years were there in countless thousands. I know of no way of estimating the number, but you may get some idea of it from the fact that the only time I was ever there at the right hour was on a trip to Eustis. The train stopped at Tavares one-half hour before sunset, and remained there something like 45 minutes. I took advantage of the occasion to see the bats emerge from the building. I had only been watching a few minutes when they began, first a single one, then two or three together, and as if the rustle started them, then they began seriously flying out of the window with incredible swiftness. There must have been at least half a hundred a second. I watched this stream of bats pouring out for half an hour or so, and was told by some of the residents of Tavares that it would continue until something like half an hour after dark, making probably two hours altogether.

It was on this trip, now seven years ago, that I was making some mosquito observations, and I have to confess that I have never seen more mosquitoes in the interior of the State than I saw at that time.

Some two years ago the opera house in question was cleaned out and converted into a packing house. I have since made inquiry of the citizens in the vicinity of Tavares and Eustis, as to whether they have experienced any appreciable difference in the number of mosquitoes now and when the bat-roost was at its height, and am convinced that the difference, to say the least, is not such as to cause one to notice it.

Again thanking you for your information, I am very truly and cordially yours,

(Signed) HIRAM BYRD.

The present month I applied to Dr. E. W. Nelson, Acting Chief, U. S. Biological Survey, for his expert opinion on this matter, and have received the following statement:

MEMORANDUM CONCERNING THE USEFULNESS OF BATS AS DESTROYERS OF MALARIA-CARRYING MOSQUITOES.

The matter of the usefulness of bats in the destruction of mosquitoes has been greatly exaggerated by the newspaper exploitation of Dr. Campbell's experiments near San Antonio, Tex. All of these articles, as well as Dr. Campbell's statement of his case, which I have read in full detail, appear to ignore the fact that there are many species of bats (each with its peculiar geographic distribution) with greatly varying habits. Only extremely few species gather in large number to roost. Among these the species inhabiting Dr. Campbell's artificial roost near San Antonio is perhaps the most gregarious of all. The bat on which Dr. Campbell is experimenting is *Nyctinomus mexicanus*, a small free-tailed bat of wide distribution along the southern border of the United States and thence southward through Mexico and the Tropics. These bats commonly roost in very great numbers in dry caves, about the roofs of houses, gables of churches, and similar places. They swarm out at night and fly over many miles of territory, not concentrating their hunt for food in definite areas as would be necessary to clean up the mosquitoes. Furthermore, examination of the food contents of the stomachs and excrement of these bats, while showing that mosquitoes are eaten by them, fails to show that these insects form any considerable part of their food.

I spent some years studying the birds and mammals of Mexico and lived a large part of that time in places where these bats are extremely abundant. Their presence in no case appeared to have the slightest influence on the prevalence of malaria. I have lived in many Mexican villages and ranches where malarial mosquitoes were swarming about the house while these bats were living in the roofs in great numbers, apparently without having the slightest influence on the number of mosquitoes present.

I have seen Dr. Campbell's statement of his case in regard to the supposed benefit from his bat-roost to the city of San Antonio. It appears evident that he fails to appreciate the fact that there are a considerable number of different species of bats living in the vicinity of San Antonio and which may be seen flying about in company with the species which inhabits his roost. I doubt if he has given the food habits of these animals sufficiently close scientific study. Owing to the popular appeal of his experiment and to his positive statements of results, his plan has received widespread and unwarranted newspaper notoriety.

As already stated, bats have distinct geographic ranges, commonly limited by climatic conditions. The bats from northern localities either migrate to warmer climates during the winter or hibernate in caves, hollow trees, or similar sheltered places. The bats from the northern States would certainly not colonize and remain permanently in the South. Neither would the bats which inhabit Dr. Campbell's bat-roost remain in the North beyond their climatic range. These bats belong to the Lower Sonoran and Tropical Zones. It is probable that within proper climatic conditions the bat being experimented upon by Dr. Campbell might be colonized

by building similar roosts or shelters to those he employs and wetting the interior with a solution of bat guano from the same species. This, I think, would attract any of these animals in the vicinity, and they probably would adopt the building as their own. This is the species of bat which inhabits the bat-guano caves of Texas. These bats and their excrement have an extremely offensive odor, which is strongly apparent about any house where they live.

In reference to the practicability of getting results by building bat-roosts in New Jersey and Pennsylvania, I would say that there is no species of bat belonging to the climatic condition found in those States which colonizes in any such swarming numbers as does the bat inhabiting Dr. Campbell's roosts. Consequently, I do not think there would be the remotest chance of successfully attracting any considerable number of these animals. Furthermore, even should a considerable number of the bats inhabiting the Middle United States be gathered in one locality, the knowledge of their food habits would indicate that their effect on mosquitoes of the district would be very slight.

E. W. NELSON,
Acting Chief Biological Survey.

In conclusion, I do not wish to be understood as entirely condemning the bat-roost idea. Dr. Campbell has been very courteous to me and to the bureau workers, and is enthusiastic about his plans. But it is obvious to me that rigid scientific experimentation must still be carried on before any of his conclusions are accepted, and, frankly, the field is not sufficiently promising to induce the government entomological service to spend money in this direction which can be used for more pressing needs.

It appears to be plain from Mr. Nelson's expert opinion that people in New Jersey need not expect any great reduction in mosquitoes to follow the erection of bat-roosts. If there is any one here who is still sanguine in this direction, I would urge him to erect a roost at his own expense and have the most careful scientific study of the results made by New Jersey's very able State Entomologist, Dr. Headlee.

In other words, the evidence in regard to southern bats is yet very conflicting, while even experimentation with northern bats seems not to justify the expense. Bats, however, do feed on injurious insects, and very likely should be protected, as the State of Texas is being urged to do.

THE ESTABLISHMENT AND CONDUCT OF CHILD HEALTH CENTERS.

PREPARED BY THE MISSOURI FORCE ENGAGED IN CHILD HYGIENE INVESTIGATION.

Recognizing the efficiency of unity of effort, the Public Health Service urges that all organizations interested in community and health improvement should combine with the State and local boards of health and form one big machine, under local leadership, for the purpose of campaigning for better health standards for children.